Intermediate Scale Coastal Behaviour: Measurement, Modelling And Prediction

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LONG TERM GOAL

Our overall goal is to achieve a better understanding and better predictions of coastal behaviour at intermediate (event/season/year/decade) scales. We aim to bring together researchers from Europe and North America to gain the best possible benefit from developments in field observation, theory and numerical modelling.

SCIENTIFIC OBJECTIVES

We are following a four-pronged collaborative approach. Data on intermediate scale behaviour from both sides of the Atlantic are being studied and ways are being sought to project these observations onto a manageable number of descriptive parameters or basic patterns. Top-down modelling uses these data products to develop black-box (data extrapolation) and grey-box (behaviour-oriented) models for the observed behaviour. Bottom-up modelling investigates the predictive potential of process-based models, making best use of process results from US and European field campaigns, combined with existing modelling expertise. There is also a vital linking activity aimed at ensuring that the data, top-down modelling and bottom-up modelling activities interact fully, in order to bring together the most productive aspects of each into a predictive capability for intermediate-scale coastal change.

APPROACH

This project is designed to create interaction between European and North American scientists who are already involved in research related to intermediate scale coastal behaviour. We have a four part approach to achieving this interaction, through workshops, exchanges, support for Research Fellows, and additional research support.

WORK COMPLETED

Workshops:

The fourth Workshop under this NICOP project was held in June 1999 in Long Island, New York, immediately prior to the Coastal Sediments '99 Conference. The overall title of the Workshop was '**Verification, Calibration or Assimilation? Examples of model-data comparisons'**. It was organised by Nathaniel Plant and Huib de Vriend (U. Twente), and was attended by 10 participants with representation from each of the seven NICOP collaborating Institutions. Each participant made a presentation, focussed generally on the link between models and field data, followed by extensive and very productive discussions. At the end of the meeting the progress of the NICOP was reviewed and plans for future activity were discussed, including planning for the next NICOP Workshops, to be held in Oregon in January 2000 (an Argus Workshop) and in Plymouth in September 2000.

The open format of the Workshop, and the extensive opportunities for discussion, were much appreciated by the participants.

Exchanges:

Cross-Atlantic exchanges and visits supported by this NICOP project are listed in table 1.

Table 1: Table of exchanges and visits between Europe and North America.

Name	Position	Home Institution	Location visited	Purpose	Dates
Stefan Aarnikhof	PhD student	Delft Uni. and Delft Hydraulics	OSU	Research on ARGUS imagery	July-October 1998
Giovanni Coco	PhD student	U. Plymouth	Long Island, NY	4th NICOP Workshop	June 1999
Huib deVriend	Professor	U. Twente	Long Island, NY	4th NICOP Workshop	June 1999
Rolf Deigaard	Assoc. Professor	ISVA/DHI	Long Island, NY	4th NICOP Workshop	June 1999
Nils Dronen	PhD student	ISVA	Long Island, NY	4th NICOP Workshop	June 1999
Edie Gallagher +support staff	PhD student	NPS, Monterey	Netherlands	COAST3D fieldwork	October/ November 1998
Rob Holman	Professor	Oregon State Uni	Teignmouth, UK	New ARGUS station	Feb 1998
David Huntley	Professor	U. Plymouth	Long Island, NY	4th NICOP Workshop	June 1999
Andy Peet	Project leader	HR Wallingford	a) Long Island, NY b) U. Delaware c) Dalhousie U.	a) 4th NICOP Workshop b) and c) Research discussions	June/ July 1999
Nathaniel Plant	Post-doctoral Fellow	U. Twente	a) San Francisco b) Long Island, NY	a) AGU Fall Meeting b) 4th NICOP Workshop	June 1999
John Stanley	Research technician	Oregon State Uni	Teignmouth, UK	New Argus station	Feb 1998
Ed Thornton	Professor	NPS, Monterey	Netherlands	COAST3D fieldwork	October/ November 1998

Further exchanges for 1999/2000 have also been planned during this year. Researchers from Plymouth, Twente and Dalhousie will attend the ARGUS Workshop being planned for January 2000. Post-doctoral Fellow Ken Kingston (Plymouth) will remain at OSU after the Workshop, for a period of around 2 months, to pursue his Genetic Algorithm/Genetic Programming analysis of ARGUS images. Gerben Ruessink and Irene van Enckevort (Utrecht University, Netherlands) plan to spend 3 months at OSU between mid-December 1999 and mid-March 2000.

Research Fellows supported:
Ken Kingston (Plymouth). PhD student. Appointed 1st October 1998. Genetic Algorithms and Neural Nets for the analysis of ARGUS images.

Brad Morris (Plymouth). Post-doctoral Fellow (25% NICOP: 75% EC INDIA Project). Video observations at Faro, Portugal, and from ARGUS station at Teignmouth, UK.
Nils Dronen, Ken Haste Andersen and Erik Ostergaard Madsen (ISVA). Research Assistants. Funded by NICOP for March and April 1999 but with continuing collaboration. Process modelling.
Andy Peet (HR Wallingford). Research Fellow. Measures of predictive skill for coastal morphodynamic models.
Nathaniel Plant (U. Twente). Post-doctoral Fellow. Appointed May 1998 (after a PhD at OSU with Rob Holman). Analysis of field data and idealised morphologic models.

Additional Research Support.
In February 1999 a new ARGUS station was established at the COAST3D site at Teignmouth, UK. Prof Rob Holman, with technician John Stanley and a PhD student (OSU) worked with Ken Kingston, Cyril Mallet, Mark Davidson and David Huntley (Plymouth) to establish a 5 camera array which is capable of viewing essentially a full 180° field of view covering the extensive outer estuary sand bank system. This system has been in operation from that date, providing imagery during the COAST3D pilot experiments during March 1999, and also during the main experiment to take place in October and November 1999. An example of the images from this site is given in figures 1 and 2. In addition to the link to the COAST3D project, Dr Cyril Mallet, a Post-doctoral Fellow funded by the EC SWAMIEE (Sediment and Water Movement in Industrialised Estuarine Environments) is involved with this ARGUS site, studying the expected cyclic motion of the Teignmouth Banks, and also assessing the prospects for measuring surface currents using the ARGUS images.

Despite heroic efforts by Mark Davidson (Plymouth) and colleagues, deployment of a pressure sensor for waves and currents at the ARGUS site at Perranporth, UK, has run into problems associated with the very exposed site. The cable connection to the pressure sensor was severed during an unusually heavy storm. However, much of the cost of the lost equipment has been recovered through an insurance claim, and an alternative means of deployment is now being planned.

RESULTS

At this midway stage of the project all of the participants are making good progress, and the list of publications below shows the accelerating productivity of the project. The following is a summary of the primary results achieved during this year.

The work of Ken Kingston and Mark Davidson (Plymouth) on the application of neural network programmes to coastal problems, and particularly the analysis of ARGUS images, has begun to produce very promising results. A paper has been accepted for publication showing that neural net techniques provide a very robust method for estimating the wave reflection coefficient of shorelines using arrays of sensors. The technique works well in the reflective wave field in front of a reflector with a performance which, unlike most other techniques, is independent of distance from the reflector.

Neural net techniques have also been shown to be highly successful in removing the apparent movement of nearshore bars seen in ARGUS images due to changing tidal and wave conditions. This work, a collaboration between Plymouth and Utrecht (Gerben Ruessink), has involved analysis of ARGUS images from the NICOP-funded site at Egmond, Netherlands, combined with in situ measurements of bar topography using the WESP (a version of the CRAB) during the COAST3D field work. A paper on this work has been submitted for publication.

A detailed investigation of 'self-organisation' modelling for beach cusps has been undertaken by Giovanni Coco and David Huntley (Plymouth). Although it appears to be difficult to distinguish between the self-organisation and edge wave hypotheses for cusp formation on the basis of cusp wavelength (it has been shown that predicted wavelengths are essentially the same), the self-organisation model provides interesting insights into the growth rates and stability of cusps under stochastic forcing. Some of the model results suggest ways in which field measurements might be used to test for self-organisation processes.

At Twente, Nathaniel Plant has been working on a number of projects related to the linking of idealised models for coastal morphology with field measurements. A simple but effective model for interannual sand bar behaviour has been developed, and, in collaboration with colleagues at Utrecht University, has been compared with observations on the Dutch coast. A linear stability analysis for beach profiles has also been developed.

The ISVA and DHI participants have concentrated primarily on process (bottom-up) modelling. Linear and non-linear stability analysis is being used to study the development of rip channels on a barred coast. The different mechanisms involved in net sediment transport in the turbulent boundary layer under regular waves and regular wave groups have been analysed, and the overall net sediment transport calculated by the use of a numerical model. Numerical modelling has also been used to study the processes involved in sediment transport over wave ripples, and the morphological development of such ripples. Detailed two-dimensional models of instabilities in a wave boundary layer have been developed, in collaboration with Tony Bowen and Diane Foster (Dalhousie U.). Sandy Duck field data has been analysed for application in modelling the hydrodynamic and sediment transport conditions during the experiment.

Andy Peet and Richard Soulsby (HR Wallingford) have continued to look for the best methods to assess model performance using various possible statistical tests. They have also started to look at methods for linking top-down models, bottom-up models and data. Basic examples of this linking are model calibration and model validation (which connects well with the skill assessment work). Other examples are data assimilation and the projection of bottom-up models onto top-down models (the latter requiring as input the specification of several free parameters). These methods allow the periodical calibration of a top-down model for morphological behaviour.

NICOP funded travel for the Naval Postgraduate School to participate in the COAST3D nearshore field experiment which took place in October and November 1998 at Egmond aan Zee, the Netherlands. An array of sonar altimeters and a side-scan sonar was mounted on the WESP (a 13m-high amphibious vehicle used for surveying the beach) to measure the small-scale morphological features that the WESP cannot resolve. The WESP made surveys of a 1500m x 500m area three or four times per week during the six week experiment, with the sonars mounted for approximately half of these surveys.

The beach at Egmond aan Zee has three or four shore parallel bars and, similar to the beach at Duck, NC (with one or two bars), the small-scale morphology is highly dependent on the large-scale morphology. However, preliminary results suggest that the pattern seen at Duck (large megaripples predominating in the inner trough, where water depths are around 2m) is not the same on the multi-barred beach at Egmond, where large bumps are seen on the seaward face of the sand bars, also at depths of approximately 2m. Possible factors driving bedform distribution and variation include changes in sediment grain size distribution, wave transformation in shallow water

and wave-driven and tidal currents. These factors were measured by other participants in the experiment and the dependence of bedforms on them is being investigated.

IMPACT/APPLICATIONS

This NICOP project aims to assess prospects for the understanding and prediction of intermediate and large-scale coastal change. This will be the theme of the final workshop, planned for the Spring of 2001. Progress made so far, in process understanding, in linking simple models and observations, in developing methods for making best use of remote video imagery, and in assessment methods for model performance, is already of practical as well as research value.

TRANSITIONS

The interlinking of a number of US and European projects, in modelling and fieldwork, is central to this NICOP project.

RELATED PROJECTS Examples are given above of the way in which the NICOP funds are creating collaborative links between US programmes, particularly the Sandy Duck field work, and European projects COAST3D, INDIA, PACE, SASME and SWAMIEE..

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Figure 1: Oblique view of Teignmouth (merging of cameras 1,2 and 3)

Figure 2: Rectified plan- view of Teignmouth (merging of 3 cameras)